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Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):
Kjær, D., Hansen, O., Henrichsen, H. H., Chenchen, J. W., Nørgaard, K., Nielsen, P. F., & Petersen, D. H. (2013). *High resolution mapping of non-patterned MRAM film stacks*. Poster session presented at 58th Annual Conference on Magnetism and Magnetic Materials, Denver, Colorado, United States.

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High resolution mapping of non-patterned MRAM film stacks

Daniel Kjaer^{1,2}, Ole Hansen^{2,3}, Henrik Hartmann Henrichsen^{2,1}, Jacob Wang Chenchen⁴, Kristian Noergaard¹, Peter Folmer Nielsen¹, and Dirch Hjorth Petersen²

¹CAPRES A/S, Diplomvej 373, DK-2800 Kgs. Lyngby, Denmark

²DTU Nanotech – Department of Micro- and Nanotechnology, Technical University of Denmark, Building 345 East, DK-2800 Kgs. Lyngby, Denmark

³CINF – Centre for Individual Nanoparticle Functionality, Technical University of Denmark, Building 345 East, DK-2800 Kgs. Lyngby, Denmark

⁴DSI – Data Storage Institute, A*STAR (Agency for Science, Technology and Research), DSI Building, 5 Engineering Drive 1, Singapore 117608, Singapore



Presenting author

Daniel Kjaer,
PhD-student
dk@capres.com



DTU Nanotech
Department of Micro- and Nanotechnology



Center for Individual Nanoparticle Functionality



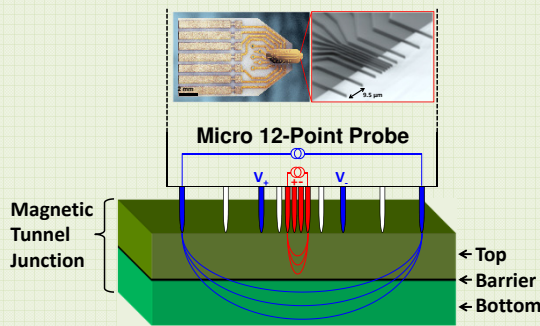
Data Storage
Institute

Production challenge¹⁻³

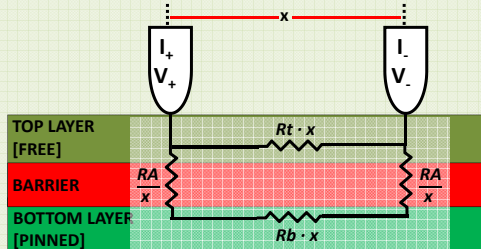
- Unacceptable RA variations across the wafer
- Optimization of production tools requires information of variations

Standard CIPT measurement routine⁴

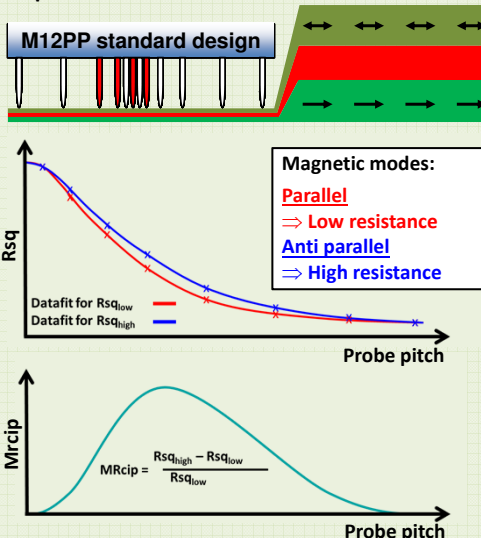
- Switching magnetic field
- R_t , R_b , TMR and RA is measured
- ~94 s / point
- Measurement time is the limiting factor for high density mapping



Two-point measurements on MTJ



Four-point measurements on MTJ



RA is the deciding parameter⁵⁻⁸

- TMR is maintained at a steady level till close proximity of the edge of the processed area
- Variations in TMR are radially symmetric
- RA starts to decrease significantly at a distance of 50 mm from the wafer center
- Variations in RA are radially asymmetric
- Full wafer map is needed for process optimization

Sample: 200 mm non-patterned MTJ, $\text{Co}_{40}\text{Fe}_{40}\text{B}_{20}/1 \text{ nm MgO}/\text{Co}_{40}\text{Fe}_{40}\text{B}_{20}$

Figure 1

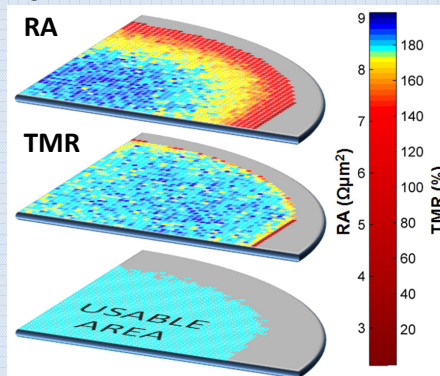


Fig. 1. Mapping of RA and TMR with 2 mm step size (1613 points) on a quarter of the sample. Usable wafer area is based on a $\pm 10\%$ limit with respect to the mean value at the center of the wafer.

Figure 2

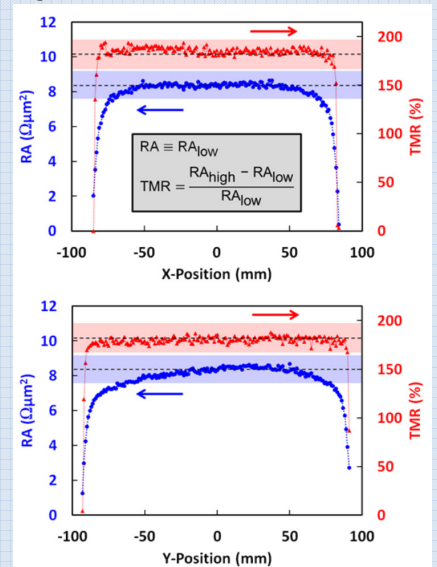


Fig. 2. Line scan measurements of RA and TMR with a step size of 1 mm along the X-axis (upper graph) and Y-axis (lower graph) across the sample. The colored areas behind the plots mark a $\pm 10\%$ band with respect to the mean values indicated by the dashed lines.

New static field CIPT measurement routine

- Static magnetic field
- R_t , R_b and RA is measured
- ~13 s / point

Measurement time is reduced by a factor of 7

Figure 3

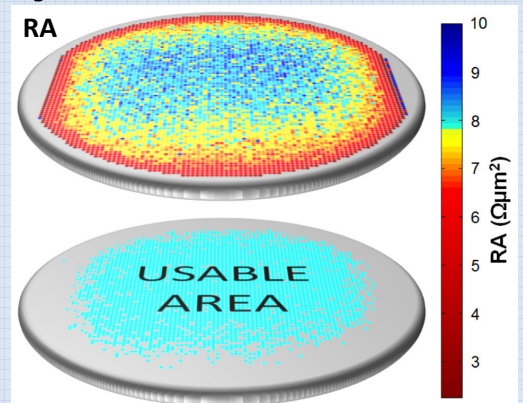


Fig. 3. High density map of RA on the full 200 mm wafer obtained with 2 mm step size totaling 6571 measurement points. The usable wafer area vs. edge exclusion zone is based on an acceptance limit of $\pm 10\%$ with respect to the mean value at the center of the wafer.

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Acknowledgements

The authors are grateful for the financial support of the Danish Ministry of Science, Innovation and Higher Education, the Danish National Research Foundation for funding the Center for Individual Nanoparticle Functionality (DNRF54), the Danish National Advanced Technology Foundation and the Villum Foundation, a non-profit foundation founded by Villum Kann Rasmussen.